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Peana et al.

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(54) **SYSTEMS AND METHODS FOR IDENTIFYING AND CORRECTING ILLUMINATION SOURCES REFLECTING ON DISPLAYS**

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CPC ***G09G 5/10*** (2013.01); ***G09G 3/3225*** (2013.01); *G09G 2320/0646* (2013.01); *G09G 2354/00* (2013.01); *G09G 2360/141* (2013.01); *G09G 2360/144* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,911,395	B1 *	3/2018	Townsend	G06F 1/1686
9,965,999	B1 *	5/2018	Barnes	G09G 3/3413
2015/0070337	A1 *	3/2015	Bell	G09G 3/007 345/207
2015/0287389	A1 *	10/2015	Mese	G09G 5/10 345/207
2017/0053604	A1 *	2/2017	Li	H05B 47/11
2018/0129262	A1 *	5/2018	Veiga	G06F 1/1681
2018/0151154	A1 *	5/2018	Lee	G02B 5/22
2018/0182357	A1 *	6/2018	Yun	G09G 5/02
2019/0213309	A1 *	7/2019	Morestin	G01S 7/4865
2019/0278368	A1 *	9/2019	Werner	G09G 5/02
2021/0104208	A1 *	4/2021	Goodsitt	G09G 5/10

* cited by examiner

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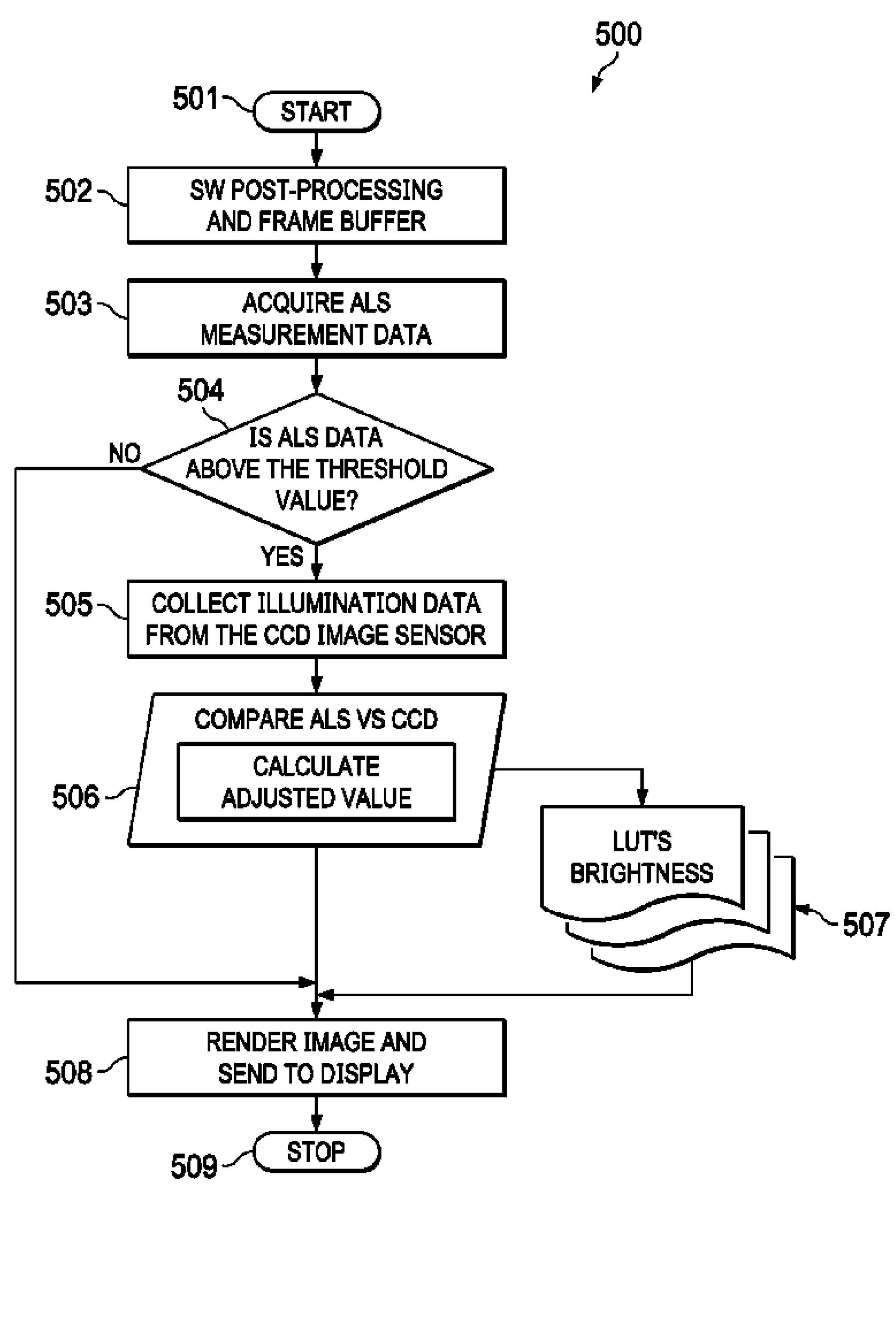
(57) **ABSTRACT**

Systems and methods for identifying and correcting illumination sources are described. In some embodiments, an Information Handling System (IHS) may include a processor and a memory coupled to the processor, the memory having program instructions stored thereon that, upon execution, cause the IHS to: receive a measurement from an Ambient Light Sensor (ALS); determine that the measurement indicates an increase in ambient illumination equal to or greater than a threshold value; in response to the determination, receive an image from a charge-coupled device (CCD) sensor; extract illumination data from the image; and adjust the measurement in response to the illumination data.

18 Claims, 6 Drawing Sheets



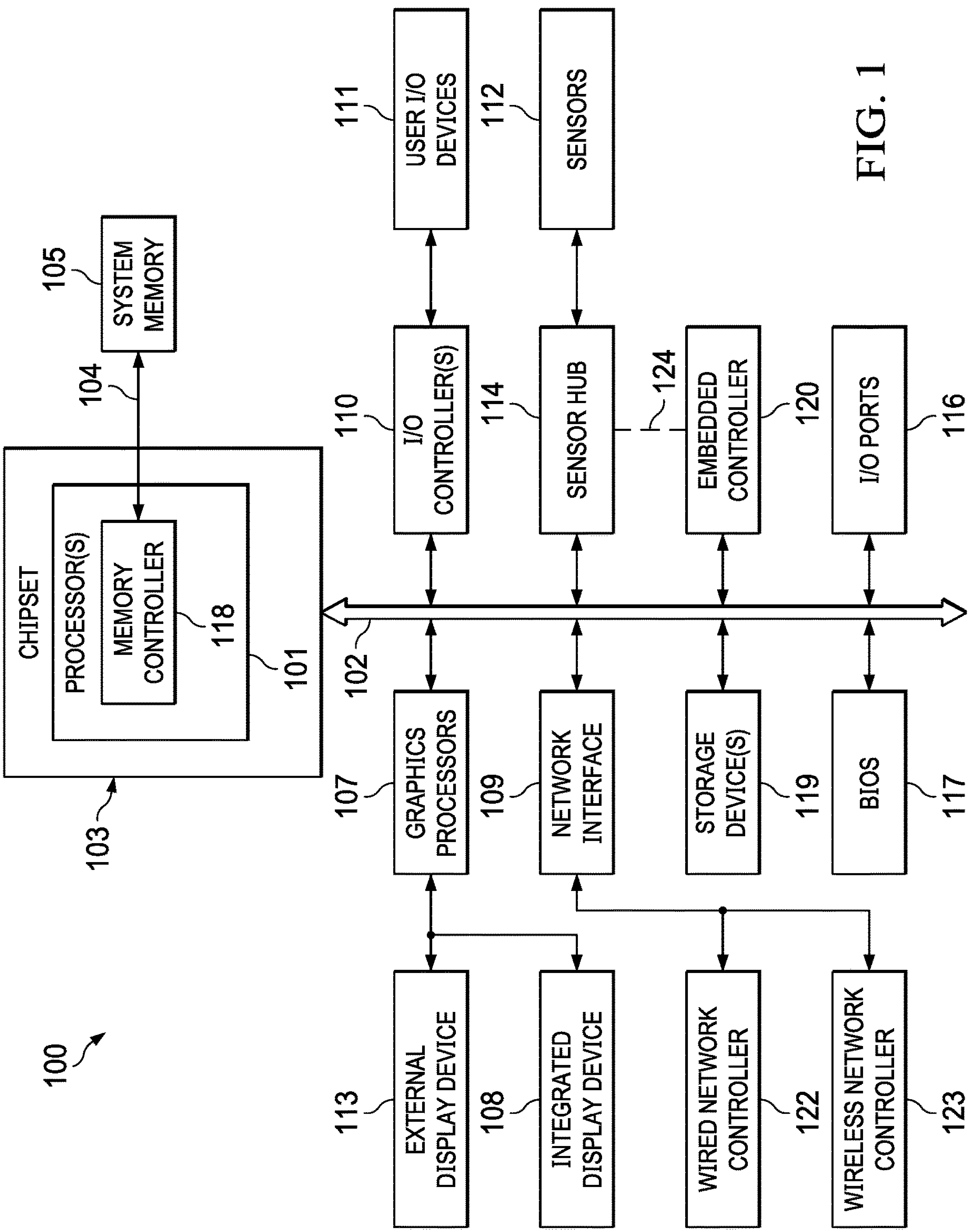

100
CHIPSET
PROCESSOR(S)
MEMORY CONTROLLER
118
101
103
SYSTEM MEMORY
105
104
102
GRAPHICS PROCESSORS
107
NETWORK INTERFACE
109
STORAGE DEVICE(S)
119
BIOS
117
EXTERNAL DISPLAY DEVICE
113
INTEGRATED DISPLAY DEVICE
108
WIRED NETWORK CONTROLLER
122
WIRELESS NETWORK CONTROLLER
123
I/O CONTROLLER(S)
110
SENSOR HUB
114
124
EMBEDDED CONTROLLER
120
I/O PORTS
116
USER I/O DEVICES
111
SENSORS
112

FIG. 1

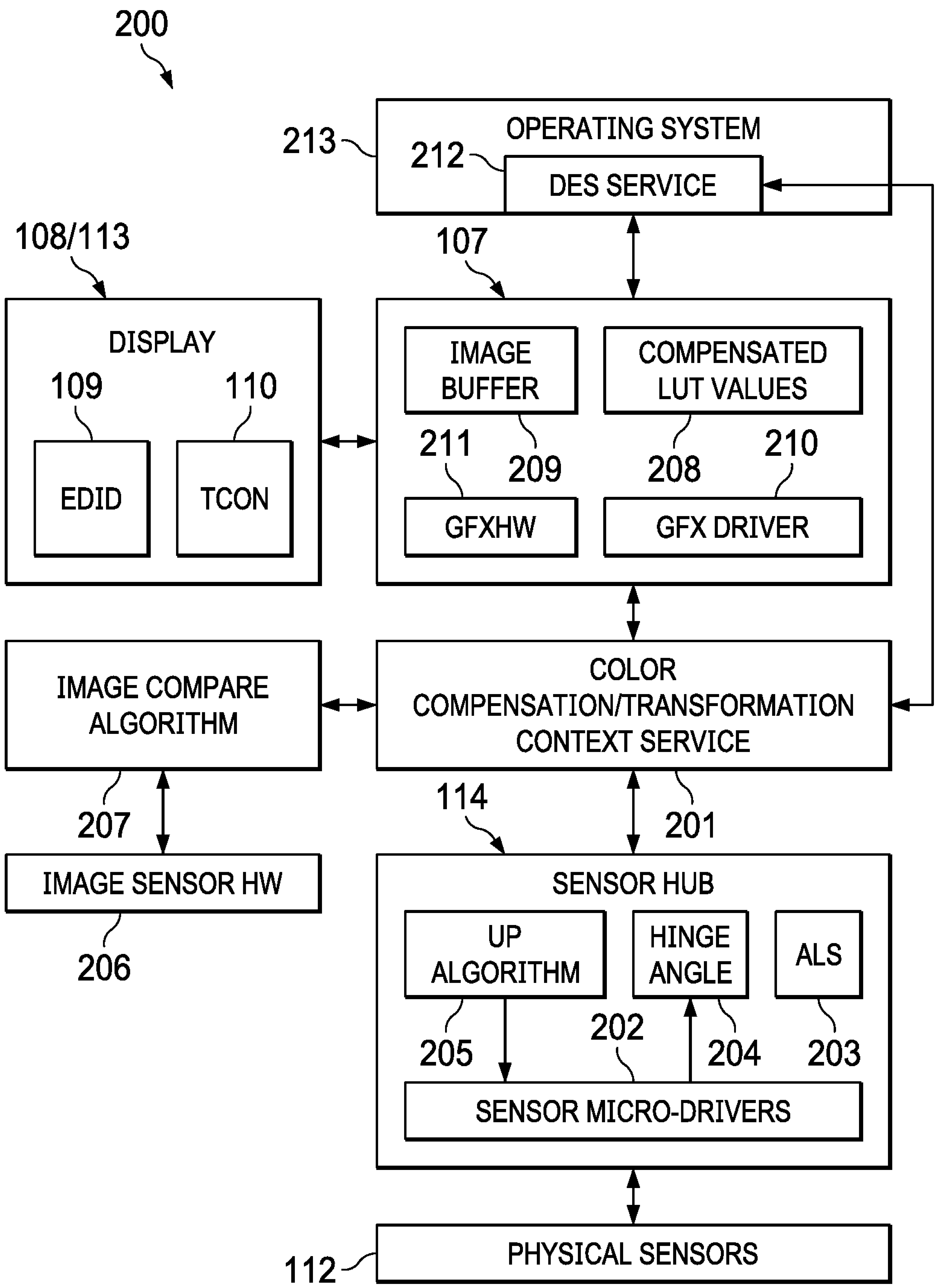

200
213
OPERATING SYSTEM
212
DES SERVICE
108/113
107
DISPLAY
109
110
EDID
TCON
IMAGE BUFFER
COMPENSATED LUT VALUES
211
209
208
210
GFXHW
GFX DRIVER
IMAGE COMPARE ALGORITHM
COLOR COMPENSATION/TRANSFORMATION CONTEXT SERVICE
207
114
201
IMAGE SENSOR HW
206
SENSOR HUB
UP ALGORITHM
HINGE ANGLE
ALS
205
202
204
203
SENSOR MICRO-DRIVERS
112
PHYSICAL SENSORS

FIG. 2

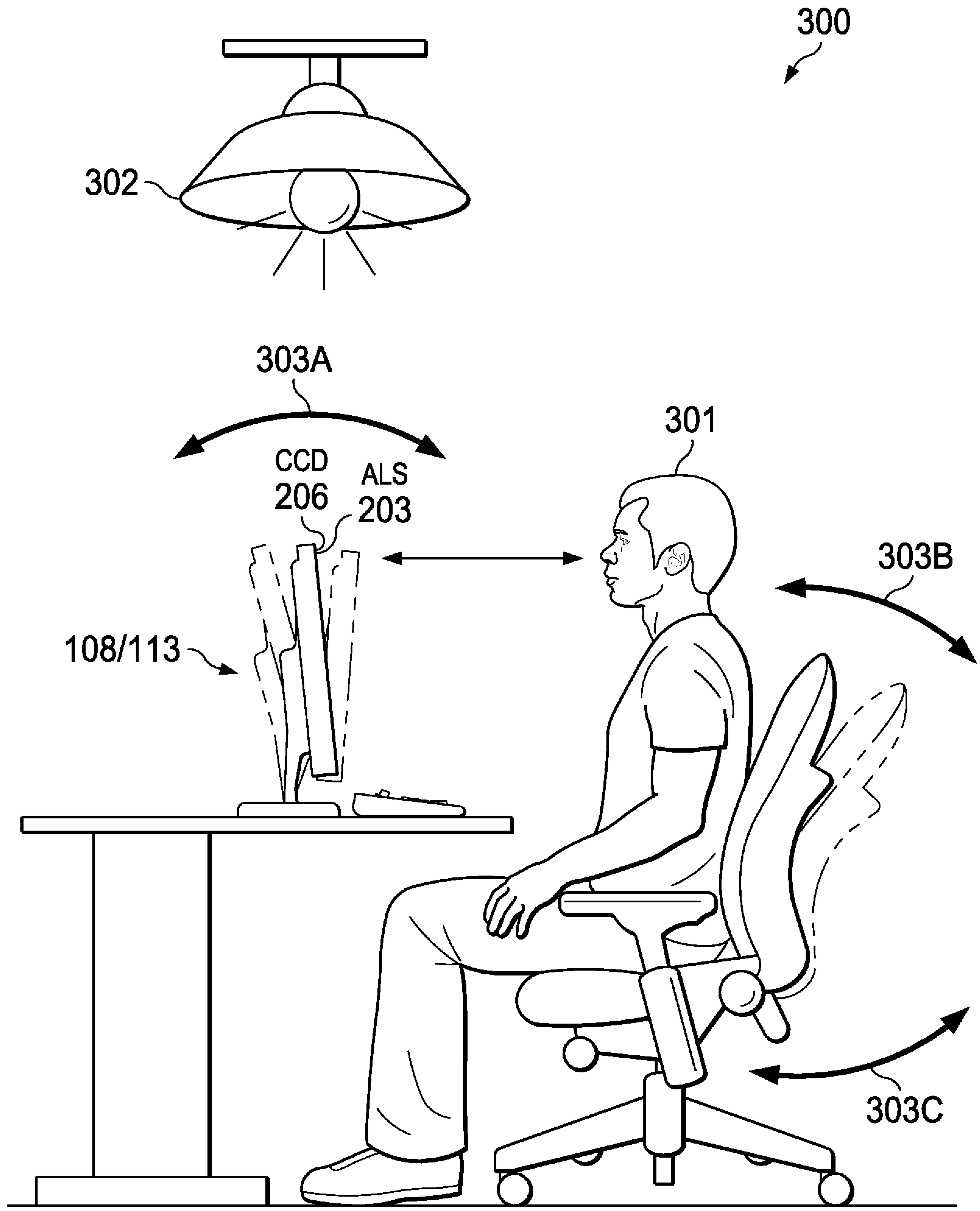


FIG. 3

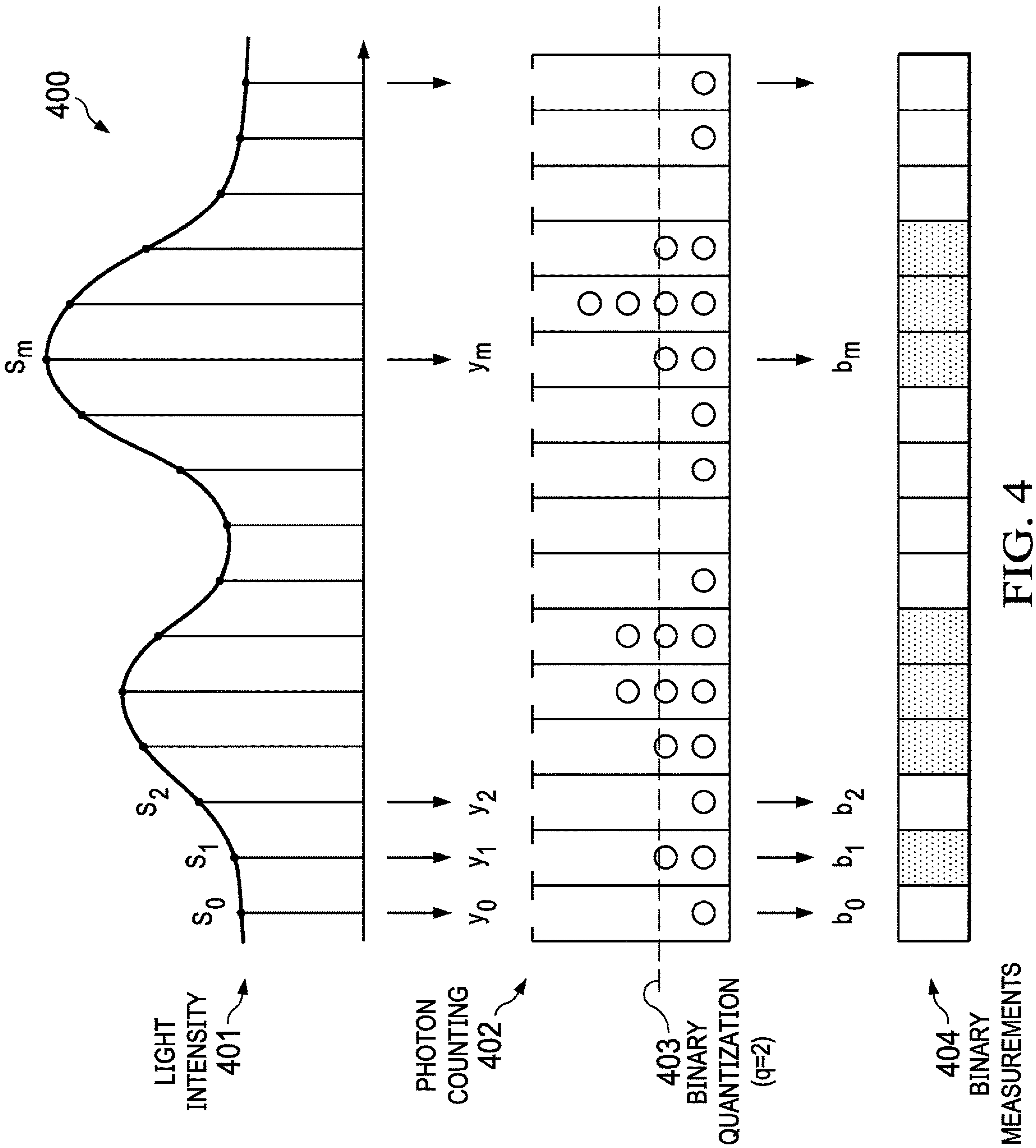

400
LIGHT INTENSITY 401
PHOTON COUNTING 402
403 BINARY QUANTIZATION (q=2)
404 BINARY MEASUREMENTS
s_0
s_1
s_2
s_m
y_0
y_1
y_2
y_m
b_0
b_1
b_2
b_m

FIG. 4

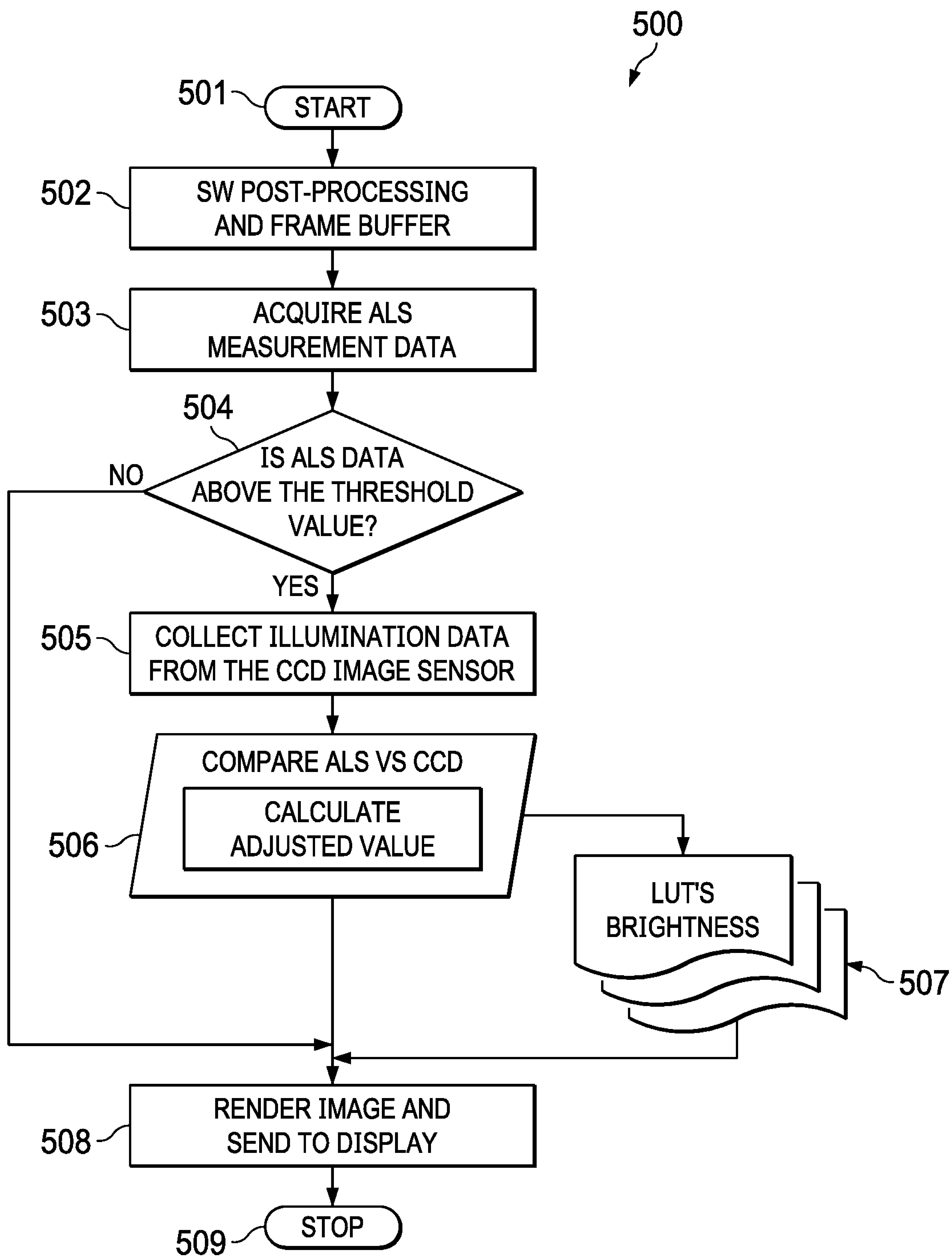

500
501
START
502
SW POST-PROCESSING AND FRAME BUFFER
503
ACQUIRE ALS MEASUREMENT DATA
504
IS ALS DATA ABOVE THE THRESHOLD VALUE?
NO
YES
505
COLLECT ILLUMINATION DATA FROM THE CCD IMAGE SENSOR
COMPARE ALS VS CCD
CALCULATE ADJUSTED VALUE
506
LUT'S BRIGHTNESS
507
RENDER IMAGE AND SEND TO DISPLAY
508
STOP
509

FIG. 5

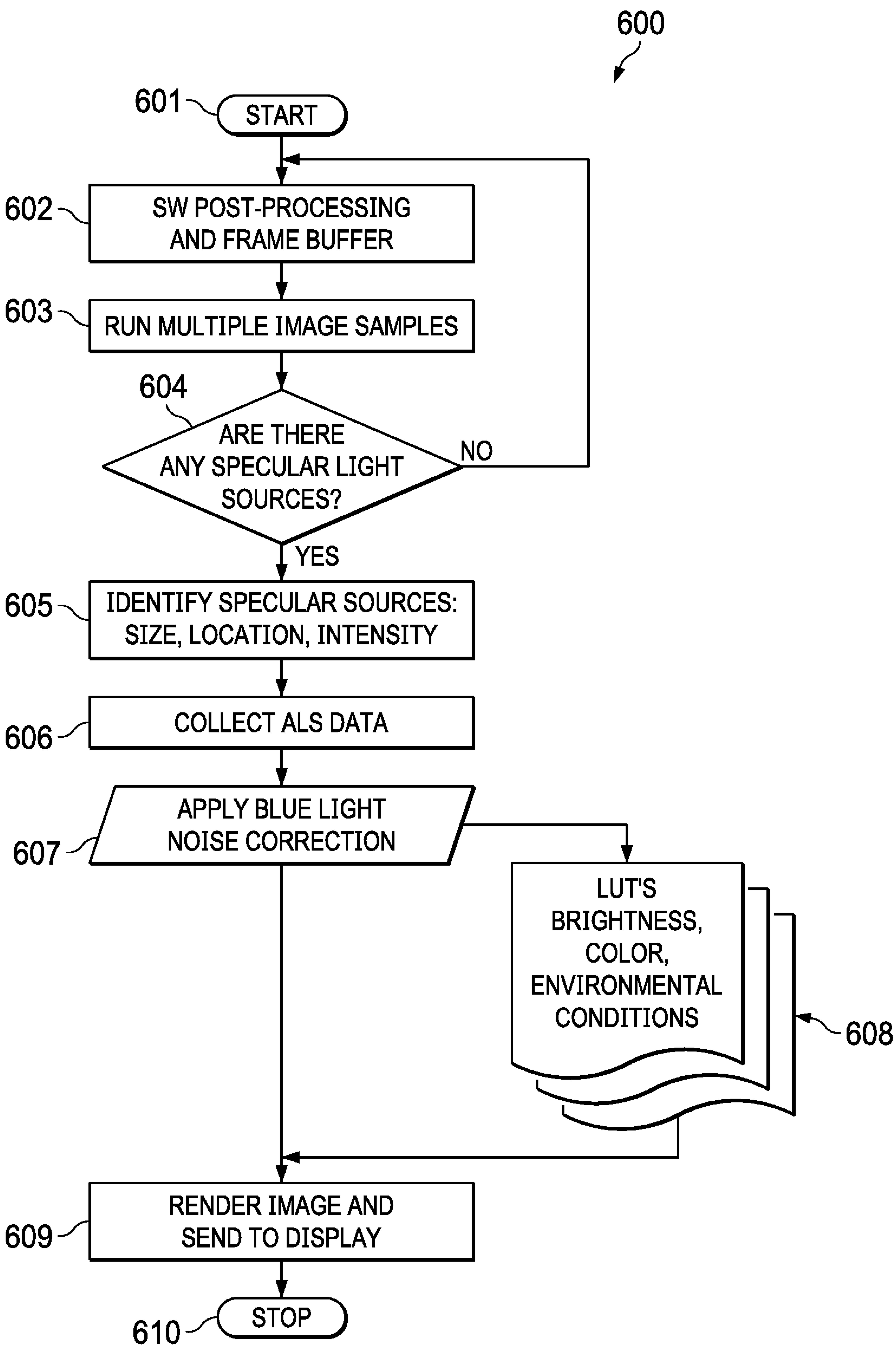

600
601
START
602
SW POST-PROCESSING
AND FRAME BUFFER
603
RUN MULTIPLE IMAGE SAMPLES
604
ARE THERE
ANY SPECULAR LIGHT
SOURCES?
NO
YES
605
IDENTIFY SPECULAR SOURCES:
SIZE, LOCATION, INTENSITY
606
COLLECT ALS DATA
607
APPLY BLUE LIGHT
NOISE CORRECTION
LUT'S
BRIGHTNESS,
COLOR,
ENVIRONMENTAL
CONDITIONS
608
609
RENDER IMAGE AND
SEND TO DISPLAY
610
STOP

FIG. 6

SYSTEMS AND METHODS FOR IDENTIFYING AND CORRECTING ILLUMINATION SOURCES REFLECTING ON DISPLAYS

FIELD

The present disclosure relates generally to Information Handling Systems (IHSs), and more particularly, to systems and methods for identifying and correcting illumination sources.

BACKGROUND

As the value and use of information continue to increase, individuals and businesses seek additional ways to process and store it. One option available to users is Information Handling Systems (IHSs). An IHS generally processes, compiles, stores, and/or communicates information or data for business, personal, or other purposes thereby allowing users to take advantage of the value of the information. Because technology and information handling needs and requirements vary between different users or applications, IHSs may also vary regarding what information is handled, how the information is handled, how much information is processed, stored, or communicated, and how quickly and efficiently the information may be processed, stored, or communicated.

Variations in IHSs allow for IHSs to be general or configured for a specific user or specific use such as financial transaction processing, airline reservations, enterprise data storage, or global communications. In addition, IHSs may include a variety of hardware and software components that may be configured to process, store, and communicate information and may include one or more computer systems, data storage systems, and networking systems.

Users typically interface with an IHS using an electronic screen, display, or monitor. Unfortunately, most IHSs can be negatively impacted by light incident onto the screen from nearby light sources. Conventional approaches for mitigating display surface reflectivity may include the use of anti-refection (AR) technologies, anti-glare (AG) technologies, or some combination of the two. Portable IHSs (e.g., tablets, laptops, etc.) currently employ the AR approach which can be generally effective in reducing diffuse reflection while maintaining image quality ("diffuse reflection" is the reflection of light from a surface such that a ray incident on the surface is scattered at many angles, rather than at just one angle, as in the case of "specular reflection").

As the inventors hereof have determined, however, office environments present a special challenge to conventional AR mitigation, in part, because light sources typically found in those environments tend to be concentrated such that the resulting specular reflection is several orders of magnitude greater than diffuse reflection. To address these, and other issues, the inventors hereof have developed systems and methods for identifying and correcting illumination sources.

SUMMARY

Embodiments of systems and methods for identifying and correcting illumination sources are described. In an illustrative, non-limiting embodiment, an Information Handling System (IHS) may include a processor and a memory coupled to the processor, the memory having program instructions stored thereon that, upon execution, cause the IHS to: receive a measurement from an Ambient Light

Sensor (ALS); determine that the measurement indicates an increase in ambient illumination equal to or greater than a threshold value; in response to the determination, receive an image from a charge-coupled device (CCD) sensor; extract illumination data from the image; and adjust the measurement in response to the illumination data.

The program instructions, upon execution, may cause the IHS to reduce the measurement using a look-up table (LUT). Additionally, or alternatively, the program instructions, upon execution by the processor, may cause the IHS to modify a brightness of a display coupled to the IHS based upon the adjusted measurement.

Additionally, or alternatively, the program instructions, upon execution, may cause the IHS to identify a light source in the image. To identify the light source, the program instructions, upon execution, may cause the IHS to determine a location, intensity, and shape of the light source. Additionally, or alternatively, the program instructions, upon execution, may cause the IHS to apply a blue light noise correction to the image based upon the identification of the light source prior to rendering the image on the display. Prior to receiving the measurement, the program instructions, upon execution, may cause the IHS to classify a location of the IHS as matching that of an office environment, and the measurement may be received in response to the classification.

In some cases, the threshold value may be selected based upon at least one of an identity of a user or a user's proximity to the IHS. Additionally, or alternatively, the threshold value may be selected based upon at least one of: an identity of an application currently under execution or a duration of execution of the application. Additionally, or alternatively, the threshold value may be selected based upon a user's gaze direction. Additionally, or alternatively, the threshold value may be selected based upon a current IHS posture. The current IHS posture may be determined by an angle of a hinge coupling two portions of the IHS.

In another illustrative non-limiting embodiment, a memory storage device having program instructions stored thereon that, upon execution by one or more processors of an IHS, cause the IHS to: receive a measurement from an ALS; determine that the measurement indicates an increase in ambient illumination equal to or greater than a threshold value; in response to the determination, receive an image from a CCD sensor; identify a light source in the image, the identification comprising a location, an intensity, and a shape of the light source; and apply a blue light noise correction to the image based upon the identification of the light source prior to rendering the image on the display.

In yet another illustrative, non-limiting embodiment, a method, may include receiving a measurement from an ALS; determining that the measurement indicates an increase in ambient illumination equal to or greater than a threshold value; in response to the determination, receiving an image from a CCD sensor; extracting illumination data from the image; adjusting the measurement in response to the illumination data; identifying a light source in the image, the identification comprising a location, an intensity, and a shape of the light source; applying a blue light noise correction to the image based upon the identification of the light source prior to rendering the image on the display; and modifying a brightness of a display coupled to the IHS based upon the adjusted measurement.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention(s) is/are illustrated by way of example and is/are not limited by the accompanying figures, in which like references indicate similar elements. Elements in the figures are illustrated for simplicity and clarity, and have not necessarily been drawn to scale.

FIG. **1** is a diagram of an example of an Information Handling System (IHS) configured to perform identification and correction of illumination sources, according to some embodiments.

FIG. **2** is a diagram illustrating an example of a system configured to perform identification and correction of illumination sources, according to some embodiments.

FIG. **3** is a diagram illustrating an example of an illumination source in an office environment, according to some embodiments.

FIG. **4** is a diagram illustrating an example of a specular light source profile, according to some embodiments.

FIG. **5** is a flowchart illustrating an example of a method for adjusting Ambient Light Sensor (ALS) measurements, according to some embodiments.

FIG. **6** is a flowchart illustrating an example of a method for identifying and correcting illumination sources, according to some embodiments.

DETAILED DESCRIPTION

Systems and methods for identifying and correcting illumination sources are described. Generally speaking, an electronic display's image quality is a weighted combination of the visually significant attributes of all objects in a displayed image. Even when if the image quality of a display were otherwise perfect, however, that image quality can be disrupted by specular light sources reflected by the display's screen.

As used herein, the term "display" generally refers to an output device that displays information in pictorial form. For example, a display may include a liquid crystal display (LCD) with light-emitting diode (LED) backlighting, an organic light-emitting diode (OLED) display, a plasma display, etc.

In some embodiments, systems and methods described herein may (a) identify the location, intensity, and shape of a specular reflected light source, and (b) diminish them or reduce their impact relative to the display's overall image quality. For example, a charge-coupled device (CCD) image sensor may be employed to identify one or more light sources in each image. Once a light source's location, intensity, and shape is identified, then a post-processing image management method may be executed to reduce or eliminate the light sources from the image, and to color rebalance the image prior to sending it to the display for rendering to the user. In some cases, blue light noise processing may be used to diminish the specular reflection by blending the light source into the background.

In other embodiments, systems and methods described herein may modify an Ambient Light Sensor (ALS) sensor's measurement accuracy to help adjust the image brightness. Conventional ALS sensors tend to be point measurement sensors thus unable to identify whether its measurements are due to ambient illumination or to an emitting light source, and erroneous readings can lead to swings in the display's brightness settings that are disruptive to the user.

For purposes of this disclosure, an Information Handling System (IHS) may include any instrumentality or aggregate of instrumentalities operable to compute, calculate, determine, classify, process, transmit, receive, retrieve, originate, switch, store, display, communicate, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, an IHS may be a personal computer (e.g., desktop or laptop), tablet computer, mobile device (e.g., Personal Digital Assistant (PDA) or smart phone), server (e.g., blade server or rack server), a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price. An IHS may include Random Access Memory (RAM), one or more processing resources such as a Central Processing Unit (CPU) or hardware or software control logic, Read-Only Memory (ROM), and/or other types of nonvolatile memory.

Additional components of an IHS may include one or more disk drives, one or more network ports for communicating with external devices as well as various I/O devices, such as a keyboard, a mouse, touchscreen, and/or a video display. An IHS may also include one or more buses operable to transmit communications between the various hardware components.

FIG. **1** is a block diagram illustrating components of IHS **100** configured to perform real-time monitoring and policy enforcement of active applications and services. As shown, IHS **100** includes one or more processors **101**, such as a Central Processing Unit (CPU), that execute code retrieved from system memory **105**. Although IHS **100** is illustrated with a single processor **101**, other embodiments may include two or more processors, that may each be configured identically, or to provide specialized processing operations. Processor **101** may include any processor capable of executing program instructions, such as an Intel Pentium™ series processor or any general-purpose or embedded processors implementing any of a variety of Instruction Set Architectures (ISAs), such as the x86, POWERPC®, ARM®, SPARC®, or MIPS® ISAs, or any other suitable ISA.

In the embodiment of FIG. **1**, processor **101** includes an integrated memory controller **118** that may be implemented directly within the circuitry of processor **101**, or memory controller **118** may be a separate integrated circuit that is located on the same die as processor **101**. Memory controller **118** may be configured to manage the transfer of data to and from the system memory **105** of IHS **100** via high-speed memory interface **104**. System memory **105** that is coupled to processor **101** provides processor **101** with a high-speed memory that may be used in the execution of computer program instructions by processor **101**.

Accordingly, system memory **105** may include memory components, such as static RAM (SRAM), dynamic RAM (DRAM), NAND Flash memory, suitable for supporting high-speed memory operations by the processor **101**. In certain embodiments, system memory **105** may combine both persistent, non-volatile memory and volatile memory. In some implementations, system memory **105** may include multiple removable memory modules.

IHS **100** utilizes chipset **103** that may include one or more integrated circuits that are connect to processor **101**. In the embodiment of FIG. **1**, processor **101** is depicted as a component of chipset **103**. In other embodiments, all of chipset **103**, or portions of chipset **103** may be implemented directly within the integrated circuitry of processor **101**. Chipset **103** provides processor **101** with access to a variety of resources accessible via bus **102**. In IHS **100**, bus **102** is illustrated as a single element. Various embodiments may utilize any number of separate buses to provide the illustrated pathways served by bus **102**.

In various embodiments, IHS **100** may include one or more I/O ports **116** that may support removeable couplings with various types of external devices and systems, including removeable couplings with peripheral devices that may be configured for operation by a particular user of IHS **100**.

For instance, I/O **116** ports may include USB (Universal Serial Bus) ports, by which a variety of external devices may be coupled to IHS **100**. In addition to or instead of USB ports, I/O ports **116** may include various types of physical I/O ports that are accessible to a user via the enclosure of the IHS **100**.

In certain embodiments, chipset **103** may additionally utilize one or more I/O controllers **110** that may each support the operation of hardware components such as user I/O devices **111** that may include peripheral components that are physically coupled to I/O port **116** and/or peripheral components that are wirelessly coupled to IHS **100** via network interface **109**. In various implementations, I/O controller **110** may support the operation of one or more user I/O devices **110** such as a keyboard, mouse, touchpad, touchscreen, microphone, speakers, camera and other input and output devices that may be coupled to IHS **100**. User I/O devices **111** may interface with an I/O controller **110** through wired or wireless couplings supported by IHS **100**. In some cases, I/O controllers **110** may support configurable operation of supported peripheral devices, such as user I/O devices **111**.

As illustrated, a variety of additional resources may be coupled to processor(s) **101** of IHS **100** through chipset **103**. For instance, chipset **103** may be coupled to network interface **109** that may support different types of network connectivity. IHS **100** may also include one or more Network Interface Controllers (NICs) **122** and **123**, each of which may implement the hardware required for communicating via a specific networking technology, such as Wi-Fi, BLUETOOTH, Ethernet and mobile cellular networks (e.g., CDMA, TDMA, LTE). Network interface **109** may support network connections by wired network controllers **122** and wireless network controllers **123**. Each network controller **122** and **123** may be coupled via various buses to chipset **103** to support different types of network connectivity, such as the network connectivity utilized by IHS **100**.

Chipset **103** may also provide access to one or more display device(s) **108** and/or **113** via graphics processor **107**. Graphics processor **107** may be included within a video card, graphics card or within an embedded controller installed within IHS **100**. Additionally, or alternatively, graphics processor **107** may be integrated within processor **101**, such as a component of a system-on-chip (SoC). Graphics processor **107** may generate display information and provide the generated information to one or more display device(s) **108** and/or **113**, coupled to IHS **100**.

One or more display devices **108** and/or **113** coupled to IHS **100** may utilize LCD, LED, OLED, or other display technologies. Each display device **108** and **113** may be capable of receiving touch inputs such as via a touch controller that may be an embedded component of the display device **108** and/or **113** or graphics processor **107**, or it may be a separate component of IHS **100** accessed via bus **102**. In some cases, power to graphics processor **107**, integrated display device **108** and/or external display **133** may be turned off or configured to operate at minimal power levels in response to IHS **100** entering a low-power state (e.g., standby).

As illustrated, IHS **100** may support integrated display device **108**, such as a display integrated into a laptop, tablet, 2-in-1 convertible device, or mobile device. IHS **100** may also support use of one or more external displays **113**, such as external monitors that may be coupled to IHS **100** via various types of couplings, such as by connecting a cable from the external display **113** to external I/O port **116** of the IHS **100**. In certain scenarios, the operation of integrated displays **108** and external displays **113** may be configured for a particular user. For instance, a particular user may prefer specific brightness settings that may vary the display brightness based on time of day and ambient lighting conditions.

Chipset **103** also provides processor **101** with access to one or more storage devices **119**. In various embodiments, storage device **119** may be integral to IHS **100** or may be external to IHS **100**. In certain embodiments, storage device **119** may be accessed via a storage controller that may be an integrated component of the storage device. Storage device **119** may be implemented using any memory technology allowing IHS **100** to store and retrieve data. For instance, storage device **119** may be a magnetic hard disk storage drive or a solid-state storage drive. In certain embodiments, storage device **119** may be a system of storage devices, such as a cloud system or enterprise data management system that is accessible via network interface **109**.

As illustrated, IHS **100** also includes Basic Input/Output System (BIOS) **117** that may be stored in a non-volatile memory accessible by chipset **103** via bus **102**. Upon powering or restarting IHS **100**, processor(s) **101** may utilize BIOS **117** instructions to initialize and test hardware components coupled to the IHS **100**. BIOS **117** instructions may also load an operating system (OS) (e.g., WINDOWS, MACOS, iOS, ANDROID, LINUX, etc.) for use by IHS **100**.

BIOS **117** provides an abstraction layer that allows the operating system to interface with the hardware components of the IHS **100**. The Unified Extensible Firmware Interface (UEFI) was designed as a successor to BIOS. As a result, many modern IHSs utilize UEFI in addition to or instead of a BIOS. As used herein, BIOS is intended to also encompass UEFI.

Certain IHS **100** embodiments may utilize sensor hub **114** capable of sampling and/or collecting data from a variety of hardware sensors **112**. For instance, sensors **112**, may be disposed within IHS **100**, and/or display **110**, and/or a hinge coupling a display portion to a keyboard portion of IHS **100**, and may include, but are not limited to: electric, magnetic, hall effect, radio, optical, infrared, thermal, force, pressure, touch, acoustic, ultrasonic, proximity, position, location, angle, deformation, bending, direction, movement, velocity, rotation, acceleration, bag state (in or out of a bag), and/or lid sensor(s) (open or closed).

In some cases, one or more sensors **112** may be part of a keyboard or other input device. Processor **101** may be configured to process information received from sensors **112** through sensor hub **114**, and to perform methods for performing real-time monitoring and policy enforcement of active applications and services using contextual information obtained from sensors **112**.

For instance, during operation of IHS **100**, the user may open, close, flip, swivel, or rotate display **108** to produce different IHS postures. In some cases, processor **101** may be configured to determine a current posture of IHS **100** using sensors **112**.

For example, in a dual-display IHS implementation, when a first display **108** (in a first IHS portion) is folded against a second display **108** (in a second IHS portion) so that the two displays have their backs against each other, IHS **100** may be said to have assumed a book posture. Other postures may include a table posture, a display posture, a laptop posture, a stand posture, or a tent posture, depending upon whether IHS **100** is stationary, moving, horizontal, resting at a different angle, and/or its orientation (landscape vs. portrait).

In a laptop posture, a first display surface of a first display **108** may be facing the user at an obtuse angle with respect to a second display surface of a second display **108** or a physical keyboard portion. In a tablet posture, a first display **108** may be at a straight angle with respect to a second display **108** or a physical keyboard portion. And, in a book posture, a first display **108** may have its back resting against the back of a second display **108** or a physical keyboard portion.

It should be noted that the aforementioned postures, and their various respective keyboard states, are described for sake of illustration. In different embodiments, other postures may be used, for example, depending upon the type of hinge coupling the displays, the number of displays used, or other accessories.

In other cases, processor **101** may process user presence data received by sensors **112** and may determine, for example, whether an IHS's end-user is present or absent. Moreover, in situations where the end-user is present before IHS **100**, processor **101** may further determine a distance of the end-user from IHS **100** continuously or at pre-determined time intervals. The detected or calculated distances may be used by processor **101** to classify the user as being in the IHS's near-field (user's position<threshold distance A), mid-field (threshold distance A<user's position<threshold distance B, where B>A), or far-field (user's position>threshold distance C, where C>B) with respect to IHS **100** and/or display **108**.

More generally, in various implementations, processor **101** may receive and/or to produce system context information using sensors **112** including one or more of, for example: a user's presence state (e.g., present, near-field, mid-field, far-field, absent), a facial expression of the user, a direction of the user's gaze, a user's gesture, a user's voice, an IHS location (e.g., based on the location of a wireless access point or Global Positioning System), IHS movement (e.g., from an accelerometer or gyroscopic sensor), lid state (e.g., of a laptop), hinge angle (e.g., in degrees), IHS posture (e.g., laptop, tablet, book, tent, and display), whether the IHS is coupled to a dock or docking station, a distance between the user and at least one of: the IHS, the keyboard, or a display coupled to the IHS, a type of keyboard (e.g., a physical keyboard integrated into IHS **100**, a physical keyboard external to IHS **100**, or an on-screen keyboard), whether the user operating the keyboard is typing with one or two hands (e.g., holding a stylus, or the like), a time of day, software application(s) under execution in focus for receiving keyboard input, whether IHS **100** is inside or outside of a carrying bag, ambient lighting, a battery charge level, whether IHS **100** is operating from battery power or is plugged into an AC power source (e.g., whether the IHS is operating in AC-only mode, DC-only mode, or AC+DC mode), a power consumption of various components of IHS **100** (e.g., CPU **101**, GPU **107**, system memory **105**, etc.).

In certain embodiments, sensor hub **114** may be an independent microcontroller or other logic unit that is coupled to the motherboard of IHS **100**. Sensor hub **114** may be a component of an integrated system-on-chip incorporated into processor **101**, and it may communicate with chipset **103** via a bus connection such as an Inter-Integrated Circuit (VC) bus or other suitable type of bus connection. Sensor hub **114** may also utilize an FC bus for communicating with various sensors supported by IHS **100**.

As illustrated, IHS **100** may utilize embedded controller (EC) **120**, which may be a motherboard component of IHS **100** and may include one or more logic units. In certain embodiments, EC **120** may operate from a separate power plane from the main processors **101** and thus the OS operations of IHS **100**. Firmware instructions utilized by EC **120** may be used to operate a secure execution system that may include operations for providing various core functions of IHS **100**, such as power management, management of operating modes in which IHS **100** may be physically configured and support for certain integrated I/O functions. In some embodiments, EC **120** and sensor hub **114** may communicate via an out-of-band signaling pathway or bus **124**.

In various embodiments, IHS **100** may not include each of the components shown in FIG. **1**. Additionally, or alternatively, IHS **100** may include various additional components in addition to those that are shown in FIG. **1**. Furthermore, some components that are represented as separate components in FIG. **1** may in certain embodiments be integrated with other components. For example, in some embodiments, all or a portion of the functionality provided by the illustrated components may instead be provided by components integrated into the one or more processor(s) **101** as an SoC.

FIG. **2** is a diagram illustrating an example of system **200** configured to perform identification and correction of illumination sources. In some cases, system **200** may be provided through the execution of program instructions stored in system memory **105** by processor **101** in cooperation with other hardware components of IHS **100**, such as graphics processor **107**, display(s) **108/113**, sensor hub **114** (e.g., configured to perform sensor fusion operations), and sensors **112** (e.g., a CCD sensor and/or an ALS sensor).

Particularly, color compensation/transformation and context service **201** is executed by processor **101** and it is in communication with DES service **213** of OS **214**. Service **201** is also in communication with sensor hub **114** and configured to receive information from physical sensors **112** after that information is received by corresponding sensor micro-drivers **202**, such as ALS **203**, hinge angle **204**, user proximity (UP) algorithm **105**, etc. Service **201** also receives images from CCD sensor **206** after processing by image processing/comparison algorithm **207**, or the like.

Upon performing methods for identifying and correcting illumination sources, such as method **500** of FIG. **5** and/or method **600** of FIG. **6**, service **201** modifies or compensates look-up table (LUT) values **208** maintained by graphics processor **107**, and these modified values (e.g., adjusted brightness, color, etc.) are then applied to images stored in buffer **209**. Display driver **210** interfaces with graphics hardware **211** to send adjusted or modified image data to timing controller (TCON) **212** of display **108** having Extended Display Identification Data (EDID) **213**.

FIG. **3** is a diagram illustrating an example of illumination source **302** in office environment **300**. Particularly, user **301** is positioned before display **208/113** in the presence of light source **302** (e.g., a point source, a line source, etc.), which produces specular reflections. Because display **108/113** can move in direction **303**A, and user **301** can move in at least directions **303**B and **303**C, the point or location of the specular reflection on the surface of display **108/113** is subject to change over time even when light source **302** is stationary with respect to environment **300**. In this implementation, display **108/113** holds CCD **206** (e.g., a camera sensor) and ALS **203** (a photosensor with tristimulus XYZ color sensing). In other implementations, however, at least one of sensors **203** or **206** may be disposed on a keyboard or IHS chassis.

FIG. **4** is a diagram illustrating an example of specular light source profile **400**. To build profile **400**, service **201** of FIG. **2** may be configured to determine, based upon data received from ALS **203**, light intensity curve **401** which, when subject to photon counting **402**, yields binary quantization data **402** (q=2). Service **201** then uses binary quantization data **402** to produce binary measurements **404**.

FIG. **5** is a flowchart illustrating an example of method **500** for adjusting ALS measurements. In some embodiments, method **500** may be performed, at least in part, by service **201** of FIG. **2** executed by processor **101** of FIG. **1**. Particularly, method **500** may be used to improve ALS sensing accuracy by leveraging CCD sensing in response to an ALS brightness measurement is sensing a jump equal to or above a threshold value. If the CCD confirms that the ALS reading is from the light source, then that measurement value may be adjusted down, for example, using empirically determined adjustment values.

Method **500** begins at block **501**. At block **502**, method **500** receives image data from buffer **212** and performs any suitable post-processing operation(s). Then, at block **503**, method **500** acquires ALS measurement data (e.g., Luminous Energy or "Qv," measured in lumen seconds (lms), Luminous Flux or "F," measured in Lumens (lm), Illuminance or "Ev," measured in Lux (lx), etc.). Block **504** determines whether the ALS measurement data is equal to or greater than selected threshold value(s). In some embodiments, these threshold value(s) may be selected based upon any combination of any of the aforementioned context information (e.g., an identity of a user or a user's proximity to the IHS, an identity of an application currently under execution or a duration of execution of the application, a user's gaze direction, a current IHS posture, an angle of a hinge, etc.).

If the ALS measurement data is below the threshold value(s), block **508** renders the image on display **108/113** and method **500** ends at block **509**. Conversely, if block **504** determines that the ALS measurement data is equal to or greater than the threshold value(s), block **505** collects illumination data from CCD image sensor **208** (e.g., an image frame), block **506** compares the data between ALS sensor **205** and CCD sensor **208**, and calculates adjusted value(s) for the original ALS measurement data. For example, block **506** may reduce the ALS measurement in a manner proportional to the difference between the illumination data from CCD image sensor **208** and the corresponding ALS measurement.

At block **507**, method **500** may modify a brightness LUT usable to render images stored in image buffer **212** on display **108/113** using the adjusted ALS measurement. For example, the modified LUT may reduce the brightness of display **108/113**. Then, block **508** renders the image on display **108/113** and method **500** ends at block **509**.

FIG. **6** is a flowchart illustrating an example of method **600** for identifying and correcting illumination sources. In some embodiments, method **600** may be performed, at least in part, by service **201** of FIG. **2** executed by processor **101** of FIG. **1**. Specifically, method **600** may be used regardless of whether ALS sensing is accurate, so long as there are specular reflecting sources in the image. In this case, the screen brightness can be adjusted as a value in between the corresponding ALS measurements and corresponding CCD measurements to mitigate the wide differences in brightness between the foreground and background (e.g., in a manner akin to identifying a proper "f-stop" for the image brightness level).

Method **600** begins at block **601**. At block **602**, method **600** receives image data from buffer **212** and performs any suitable post-processing operation(s). At block **603**, method **300** collets and analyzes multiple image samples. Block **604** determines, based upon the analysis of block **603**, whether there are any specular light sources (e.g., source **302**) in the acquired images. Block **605** identifies characteristics of the specular light sources such as location, size, shape, intensity, etc. Then, block **606** collects ALS measurement data.

At block **607**, method **600** may apply a correction to the images stored in frame buffer **212** (e.g., blue light noise correction, etc.). Particularly, block **607** may calculate color, brightness, and/or other corrections to compensate for the specular light source, and it may apply those corrections to corresponding LUTs at block **608**. Finally, block **609** renders the corrected images on display **108/113**, and method **600** ends at block **610**.

It should be understood that various operations described herein may be implemented in software executed by processing circuitry, hardware, or a combination thereof. The order in which each operation of a given method is performed may be changed, and various operations may be added, reordered, combined, omitted, modified, etc. It is intended that the invention(s) described herein embrace all such modifications and changes and, accordingly, the above description should be regarded in an illustrative rather than a restrictive sense.

The terms "tangible" and "non-transitory," as used herein, are intended to describe a computer-readable storage medium (or "memory") excluding propagating electromagnetic signals; but are not intended to otherwise limit the type of physical computer-readable storage device that is encompassed by the phrase computer-readable medium or memory. For instance, the terms "non-transitory computer readable medium" or "tangible memory" are intended to encompass types of storage devices that do not necessarily store information permanently, including, for example, RAM. Program instructions and data stored on a tangible computer-accessible storage medium in non-transitory form may afterwards be transmitted by transmission media or signals such as electrical, electromagnetic, or digital signals, which may be conveyed via a communication medium such as a network and/or a wireless link.

Although the invention(s) is/are described herein with reference to specific embodiments, various modifications and changes can be made without departing from the scope of the present invention(s), as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the present invention(s). Any benefits, advantages, or solutions to problems that are described herein with regard to specific embodiments are not intended to be construed as a critical, required, or essential feature or element of any or all the claims.

Unless stated otherwise, terms such as "first" and "second" are used to arbitrarily distinguish between the elements such terms describe. Thus, these terms are not necessarily intended to indicate temporal or other prioritization of such elements. The terms "coupled" or "operably coupled" are defined as connected, although not necessarily directly, and not necessarily mechanically. The terms "a" and "an" are defined as one or more unless stated otherwise. The terms "comprise" (and any form of comprise, such as "comprises" and "comprising"), "have" (and any form of have, such as "has" and "having"), "include" (and any form of include, such as "includes" and "including") and "contain" (and any form of contain, such as "contains" and "containing") are open-ended linking verbs. As a result, a system, device, or apparatus that "comprises," "has," "includes" or "contains" one or more elements possesses those one or more elements but is not limited to possessing only those one or more elements. Similarly, a method or process that “comprises,” “has,” “includes” or “contains” one or more operations possesses those one or more operations but is not limited to possessing only those one or more operations.

The invention claimed is:

1. An Information Handling System (IHS), comprising:

a processor; and

a memory coupled to the processor, the memory having program instructions stored thereon that, upon execution, cause the IHS to:

receive a measurement from an Ambient Light Sensor (ALS);

determine that the measurement indicates an increase in ambient illumination equal to or greater than a threshold value;

in response to the determination, receive an image from a charge-coupled device (CCD) sensor;

extract illumination data from the image;

reduce the measurement in proportion to the difference between the illumination data and the measurement to produce an adjusted value; and

adjust the measurement by the adjusted value.

2. The IHS of claim **1**, wherein to adjust the measurement, the program instructions, upon execution, further cause the IHS to reduce the measurement using a look-up table (LUT).

3. The IHS of claim **1**, wherein the program instructions, upon execution by the processor, cause the IHS to modify a brightness of a display coupled to the IHS based upon the adjusted measurement, wherein the display comprises an Organic Light-Emitting Diode (OLED) panel.

4. The IHS of claim **1**, wherein the program instructions, upon execution, further cause the IHS to identify a light source in the image.

5. The IHS of claim **4**, wherein to identify the light source, the program instructions, upon execution, further cause the IHS to determine a location, intensity, and shape of the light source.

6. The IHS of claim **5**, wherein the program instructions, upon execution, further cause the IHS to apply a blue light noise correction to the image based upon the identification of the light source prior to rendering the image on the display.

7. The IHS of claim **1**, wherein prior to receiving the measurement, the program instructions, upon execution, further cause the IHS to classify a location of the IHS as matching that of an office environment, and wherein the measurement is received in response to the classification.

8. The IHS of claim **1**, wherein the threshold value is selected based upon at least one of an identity of a user or a user’s proximity to the IHS.

9. The IHS of claim **1**, wherein the threshold value is selected based upon at least one of: an identity of an application currently under execution or a duration of execution of the application.

10. The IHS of claim **1**, wherein the threshold value is selected based upon a user’s gaze direction.

11. The IHS of claim **1**, wherein the threshold value is selected based upon a current IHS posture.

12. The IHS of claim **11**, wherein the current IHS posture is determined by an angle of a hinge coupling two portions of the IHS.

13. A non-transitory memory storage device having program instructions stored thereon that, upon execution by one or more processors of an Information Handling System (IHS), cause the IHS to:

receive a measurement from an Ambient Light Sensor (ALS);

determine that the measurement indicates an increase in ambient illumination equal to or greater than a threshold value, wherein the threshold value is selected based upon the identity of the user;

in response to the determination, receive an image from a charge-coupled device (CCD) sensor;

identify a light source in the image, the identification comprising a location, an intensity, and a shape of the light source;

apply a blue light noise correction to the image based upon the identification of the light source prior to rendering the image on a display coupled to the IHS;

extract illumination data from the image;

reduce the measurement in proportion to the difference between the illumination data and the measurement to produce an adjusted measurement; and

modify a brightness of the display based upon the adjusted measurement.

14. The memory storage device of claim **13**, wherein the threshold value is selected also based upon at least one of: a user’s proximity to the IHS or a user’s gaze direction.

15. The memory storage device of claim **13**, wherein the threshold value is selected also based upon a current IHS posture.

16. A method, comprising:

receiving a measurement from an Ambient Light Sensor (ALS);

determining that the measurement indicates an increase in ambient illumination equal to or greater than a threshold value, wherein the threshold value is selected based upon at least one of: an identity of an application currently under execution or a duration of execution of the application;

in response to the determination, receiving an image from a charge-coupled device (CCD) sensor;

extracting illumination data from the image;

adjusting the measurement in response to the illumination data by reducing the measurement in proportion to the difference between the illumination data and the measurement;

identifying a light source in the image, the identification comprising a location, an intensity, and a shape of the light source;

applying a blue light noise correction to the image based upon the identification of the light source prior to rendering the image on the display; and

modifying a brightness of a display coupled to an Information Handling System (IHS) based upon the adjusted measurement.

17. The method of claim **16**, wherein the threshold value is selected also based upon at least one of: an identity of a user, a user’s proximity to the IHS, or a user’s gaze direction.

18. The method of claim **16**, wherein the threshold value is selected also based upon a current IHS posture.

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